



# **Armed Forces College of Medicine AFCM**



# **Cardiac Muscle & Smooth Muscle**

***Presented by  
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Histology Department***

# INTENDED LEARNING OBJECTIVES (ILO)



By the end of this lecture the student will be able to:

1. Correlate light and electron microscopic pictures of cardiac muscle with reference to their regenerative capacities.
2. Outline the differences between the **Purkinje fibers** & the **cardiac muscle fibers**.
3. Correlate light and electron microscopic pictures of smooth muscles with reference to their regenerative capacities.
4. Compare between the **cardiac muscle** and the **smooth muscle**.

# Lecture Plan



## **1. Part 1 (5 min) Introduction**

## **2. Part 2 (35 min) Main lecture: Key points:**

- L/M of cardiac muscle
- E/M of cardiac muscle with special reference to intercalated discs.
- Growth and regeneration of the cardiac muscle.
- Structure of the wall of the heart.
- Moderator band.
- L/M of smooth muscle.
- E/M of smooth muscle.
- Growth and regeneration of smooth muscle

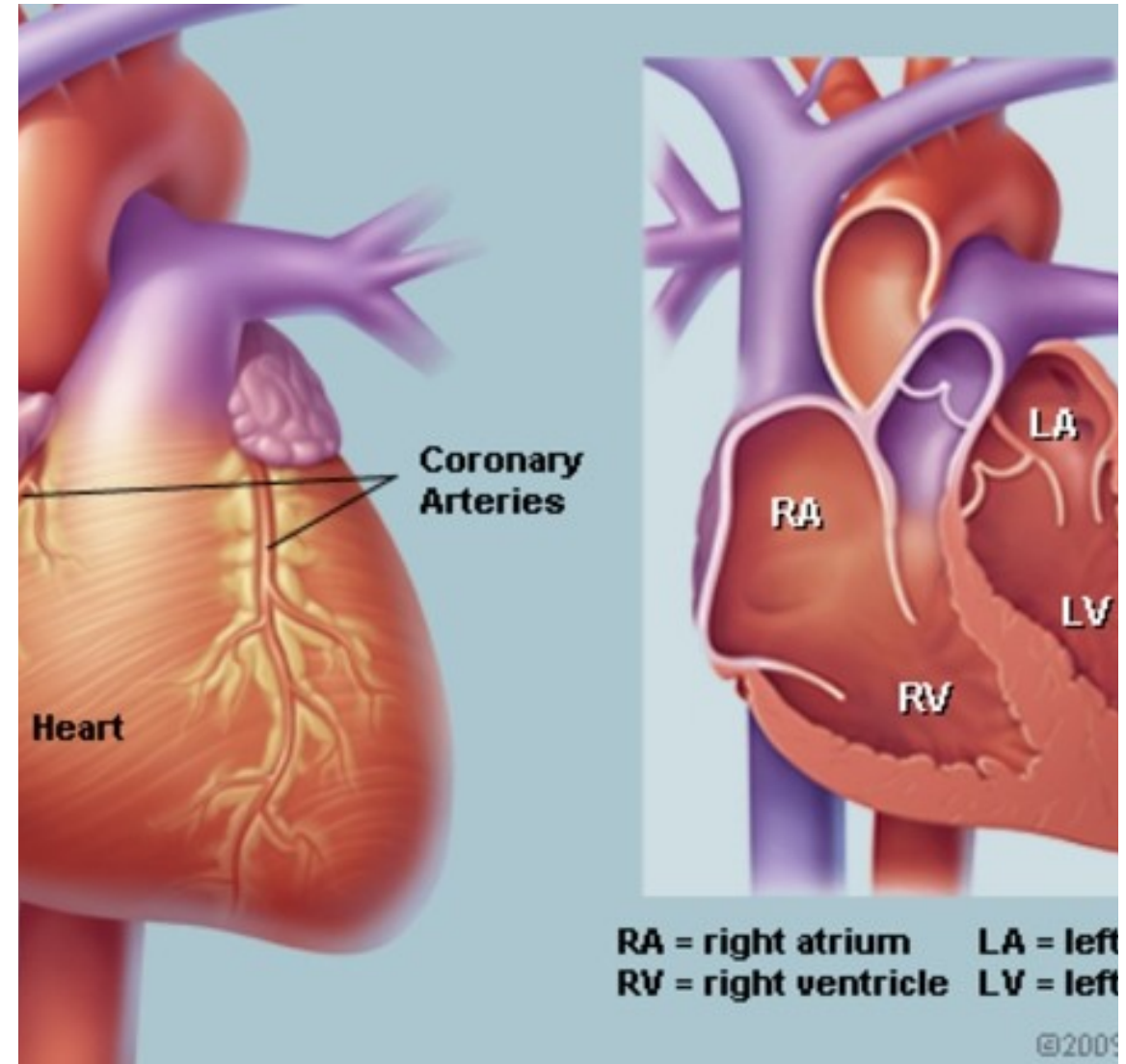
## **3. Part 3 (5 min) Summary**

# The Cardiac Muscle

**A) Origin:** mesodermal

**B) Site:**

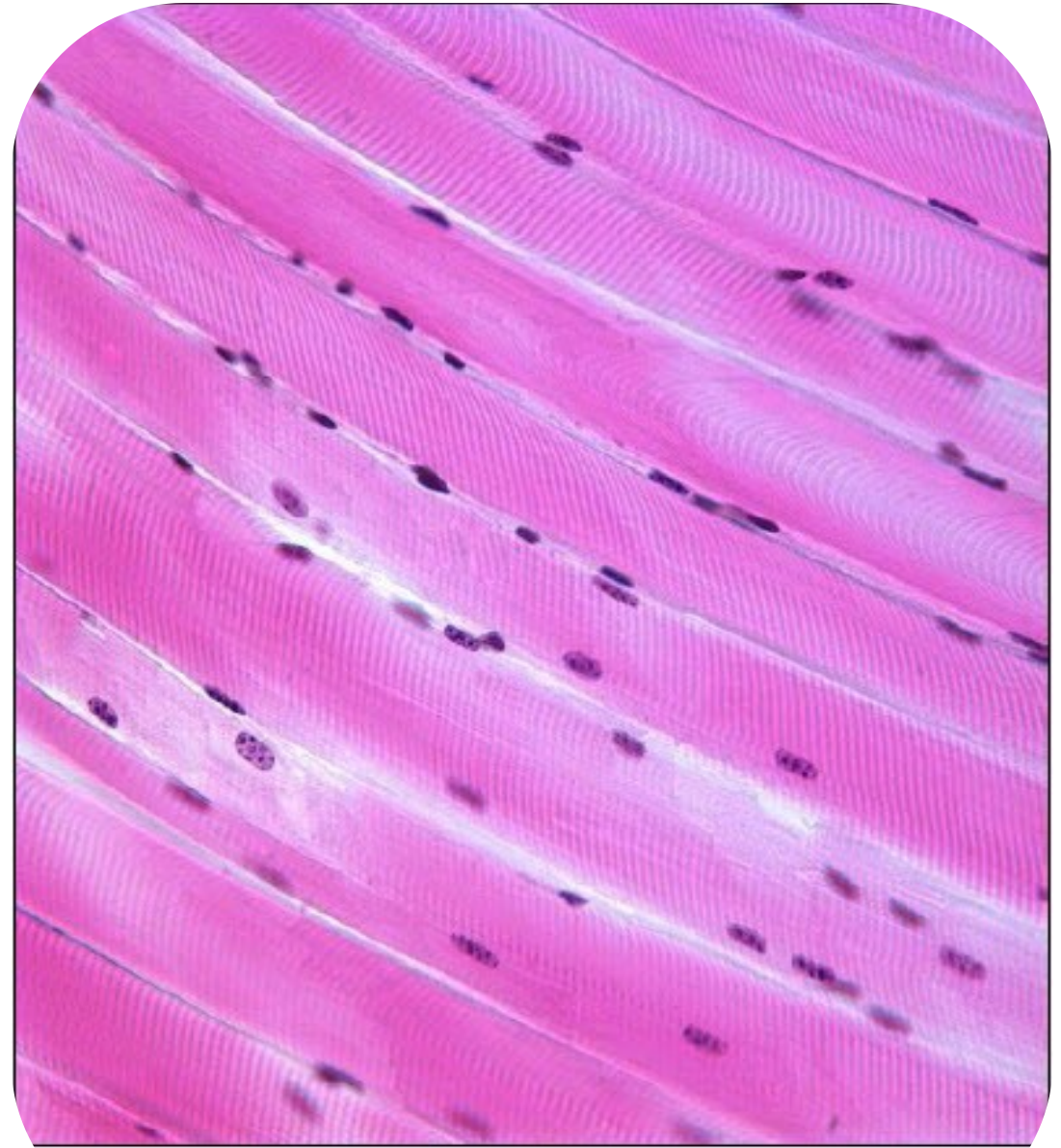
- 1- The **myocardium** of the heart
- 2- **Terminal ends of large veins** pouring their blood to the heart :
  - Pulmonary veins
  - Superior vena cava
  - Inferior vena cava.







**Cardiac muscle fibers - H&E**



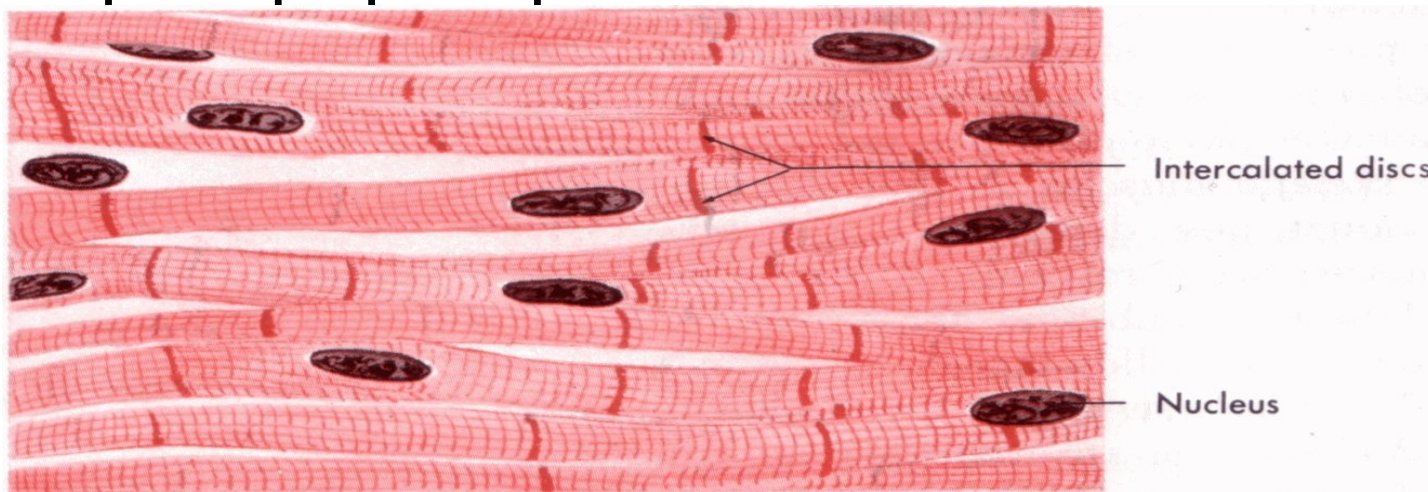
**Skeletal muscle fibers – H & E**



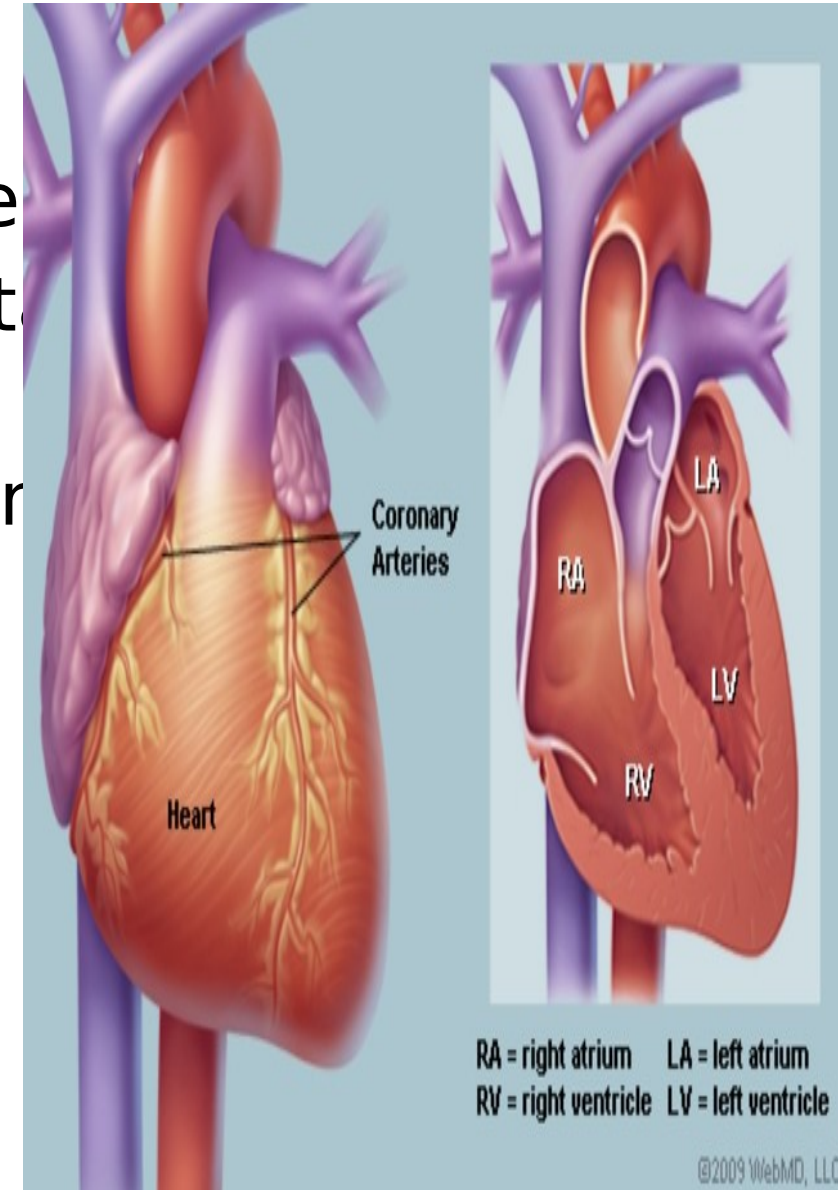
# LM of Cardiac Muscle

- L.M:

1. Cylindrical in shape.
  2. They are branching & anastomosing fibers.
  3. They are smaller in diameter than skeletal muscles.
  4. Nucleus: single, oval & central in position.
- They are arranged spirally around each



Cardiac or striated involuntary muscle tissue.



RA = right atrium    LA = left atrium  
RV = right ventricle    LV = left ventricle

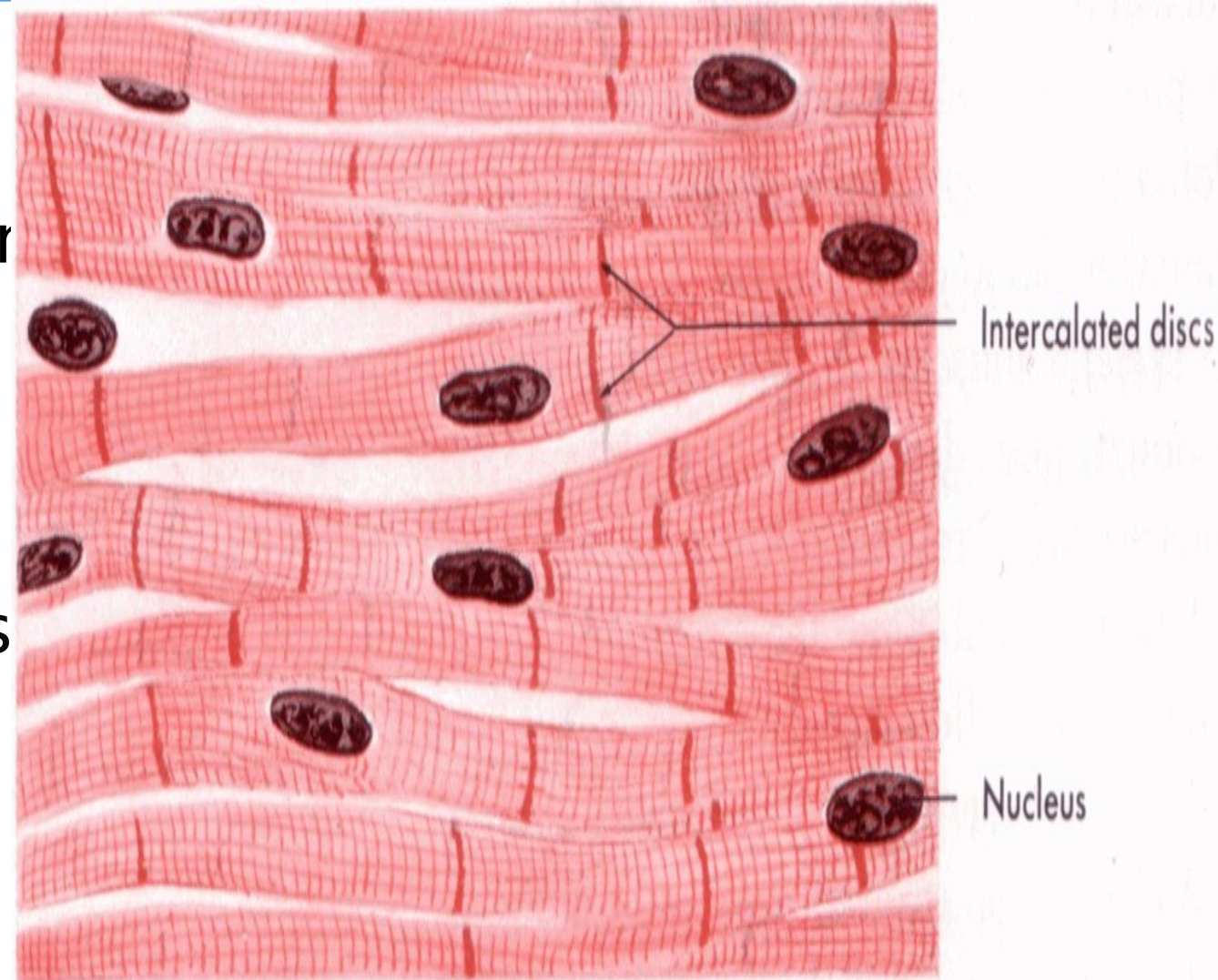
## LM of Cardiac Muscle

### 5.The cytoplasm:-

- Moderately acidophilic.
- It shows less distinct striation comparison to skeletal ms.??????

6.The cardiac m. cells are attached to each other by **Intercalated discs**→ results **fibers** of variable length.

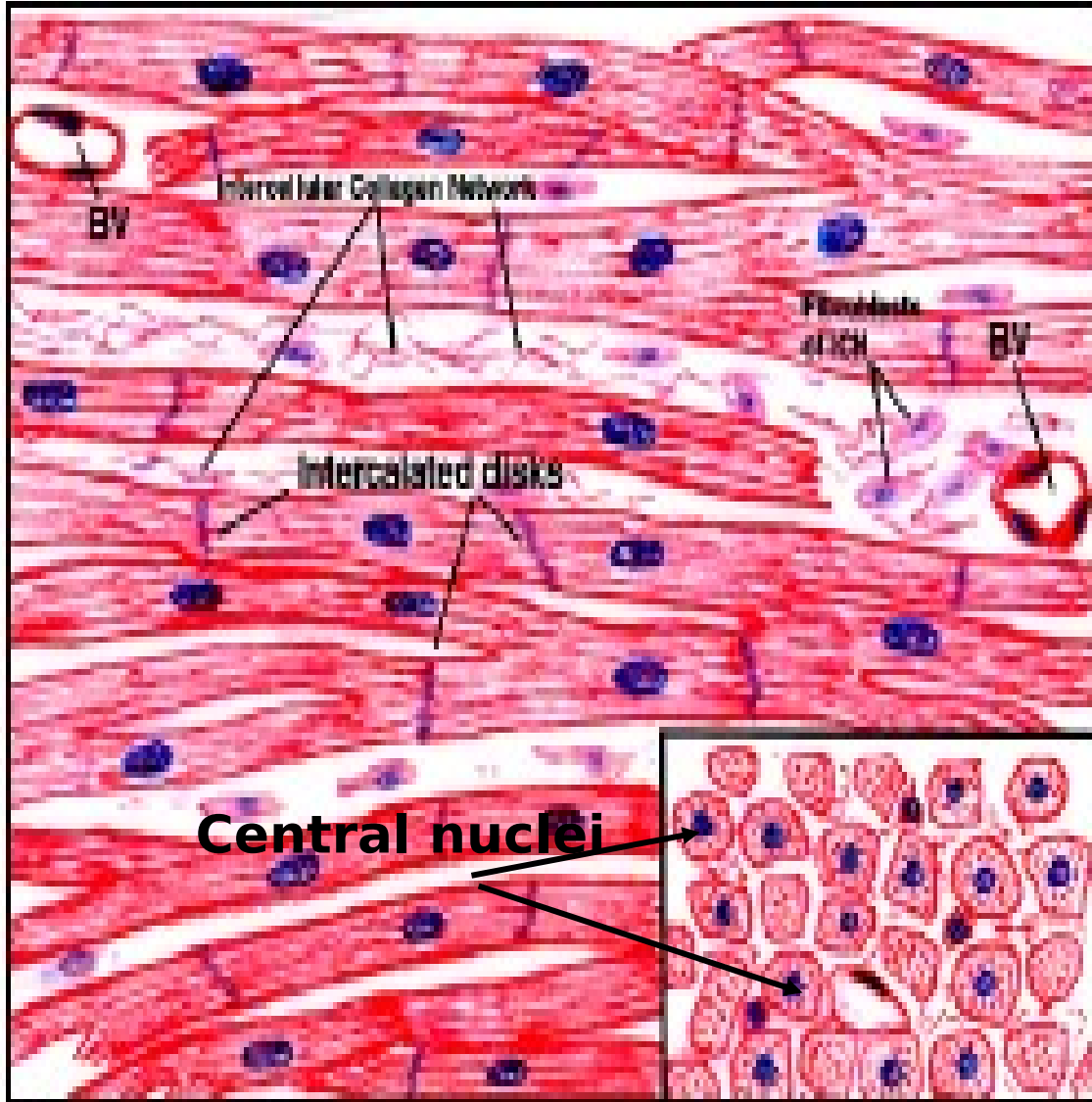
❑ **No satellite cells**



<https://www.pinterest.com/pin/695524736179796939/?lp=true>

Cardiac or striated involuntary muscle tissue.





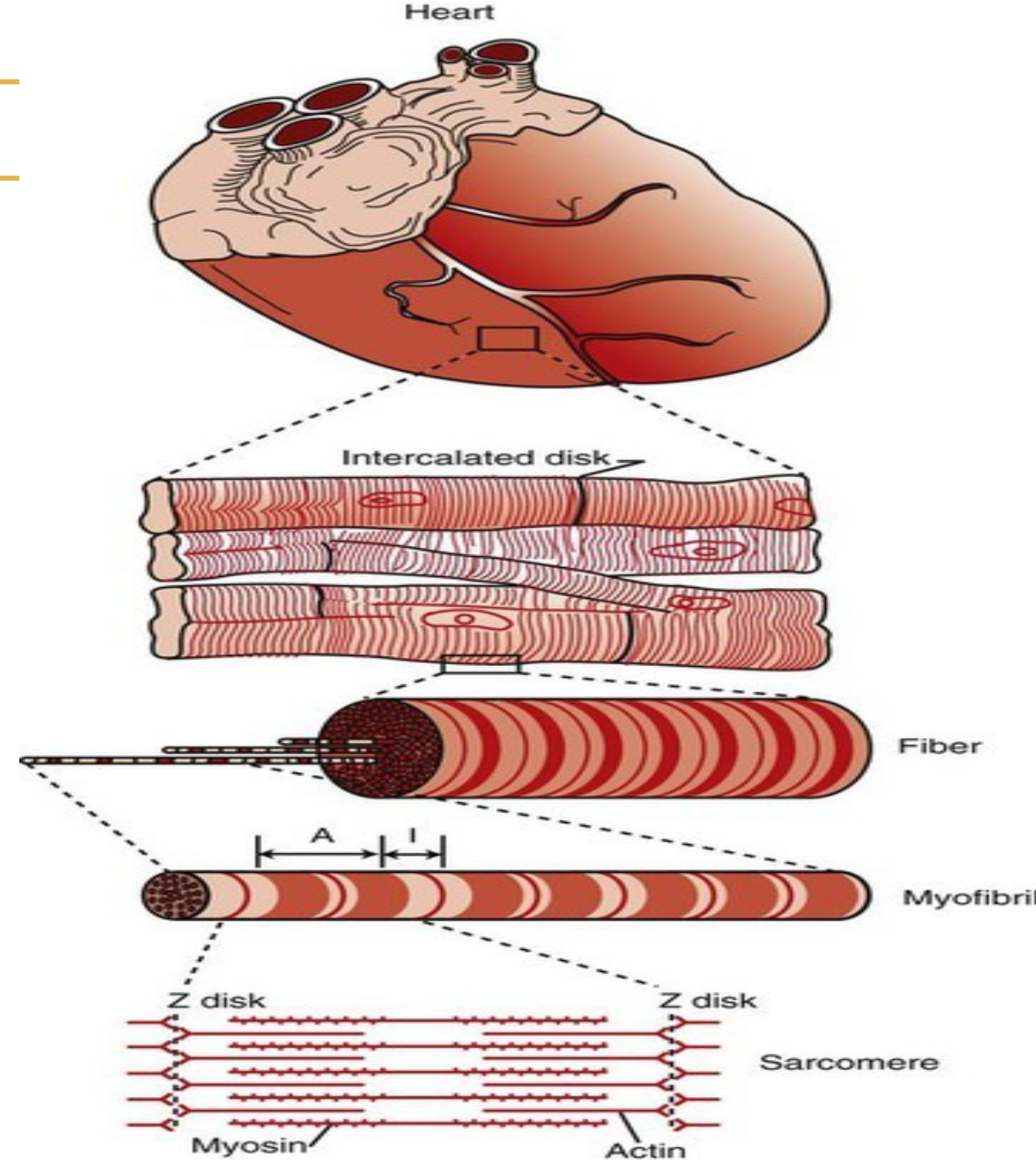
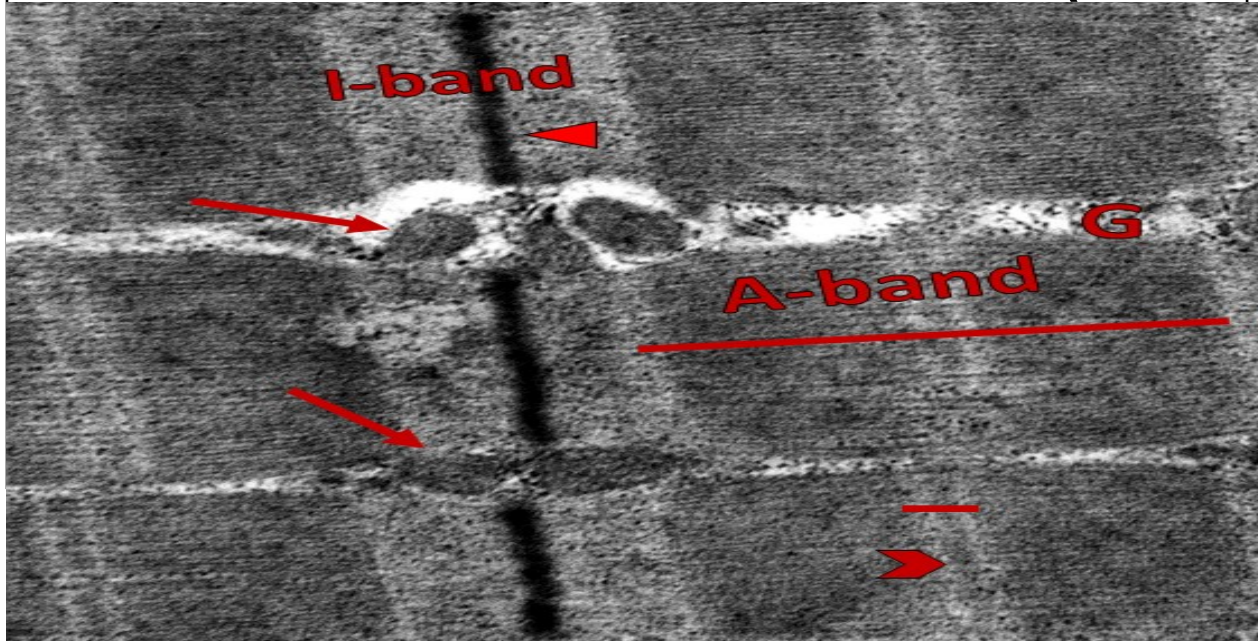
## **Γ. S. of cardiac muscle fibers :**

- 1) The fibers are rounded or oval in shape.**
- 2) The fibers are of variable diameters.**
- 3) Their nuclei are rounded and central.**

# EM of Cardiac Muscle

## 1. Myofibrils & Myofilaments:

- ❑ Thin actin & thick myosin myofilaments are forming **sarcomeres** between two Z lines. (A-





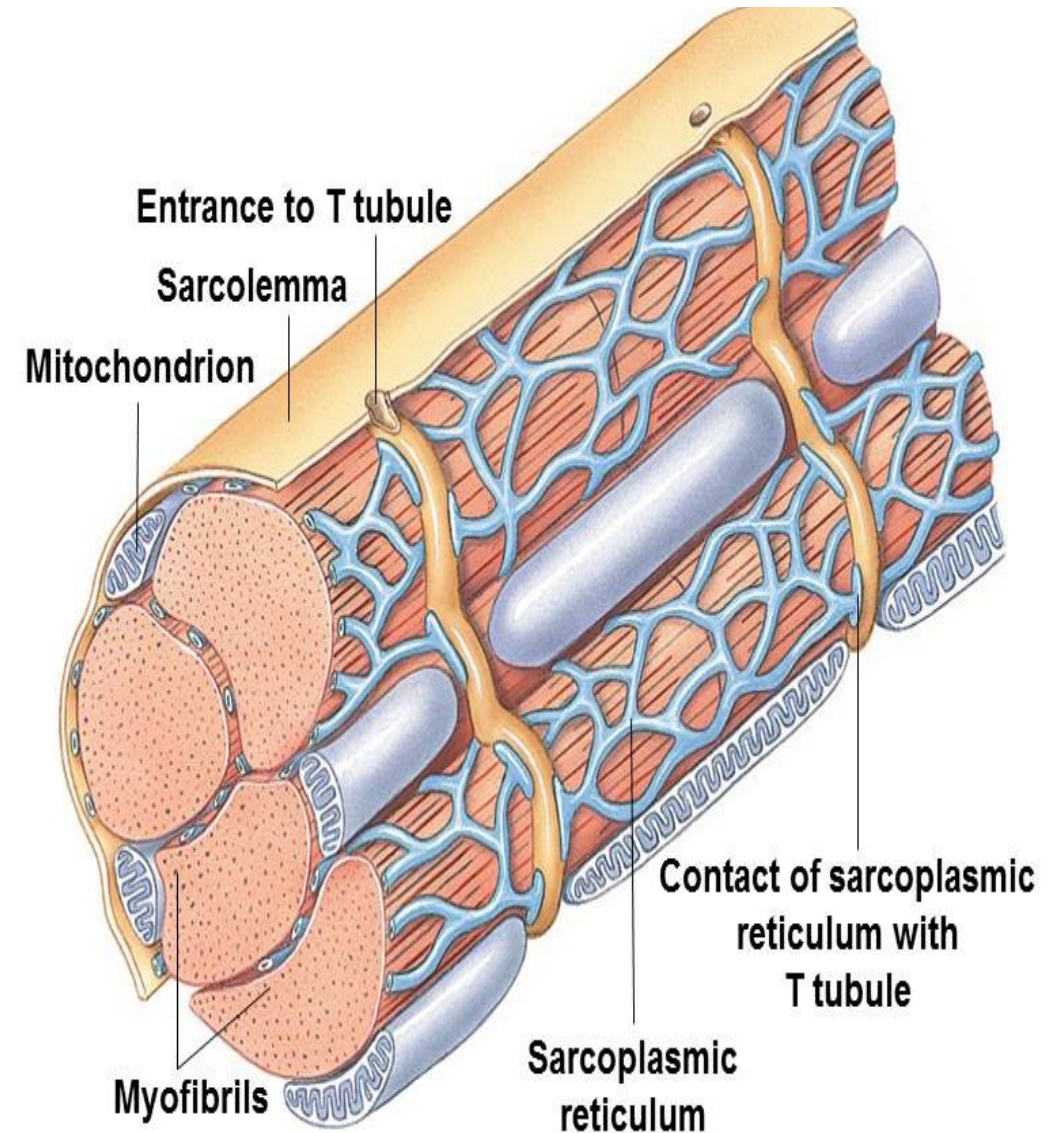
## EM of Cardiac Muscle

### 2. Cardiac T -tubules:

- ❑ Wider than those of skeletal ms.
- ❑ Lined with external lamina.
- ❑ Occur at Z line.
- ❑ Associated with single cisterna of SR

### 3. Sarcoplasmic Reticulum:-

- It is **less developed** than in skeletal ms.
- It forms **single** expanded cisternae along one side of T-tubules **at Z line**.
- There is one **Diad** for each sarcomere.



**c** Cardiac muscle tissue showing short, broad T-tubules and SR that lacks terminal cisternae.



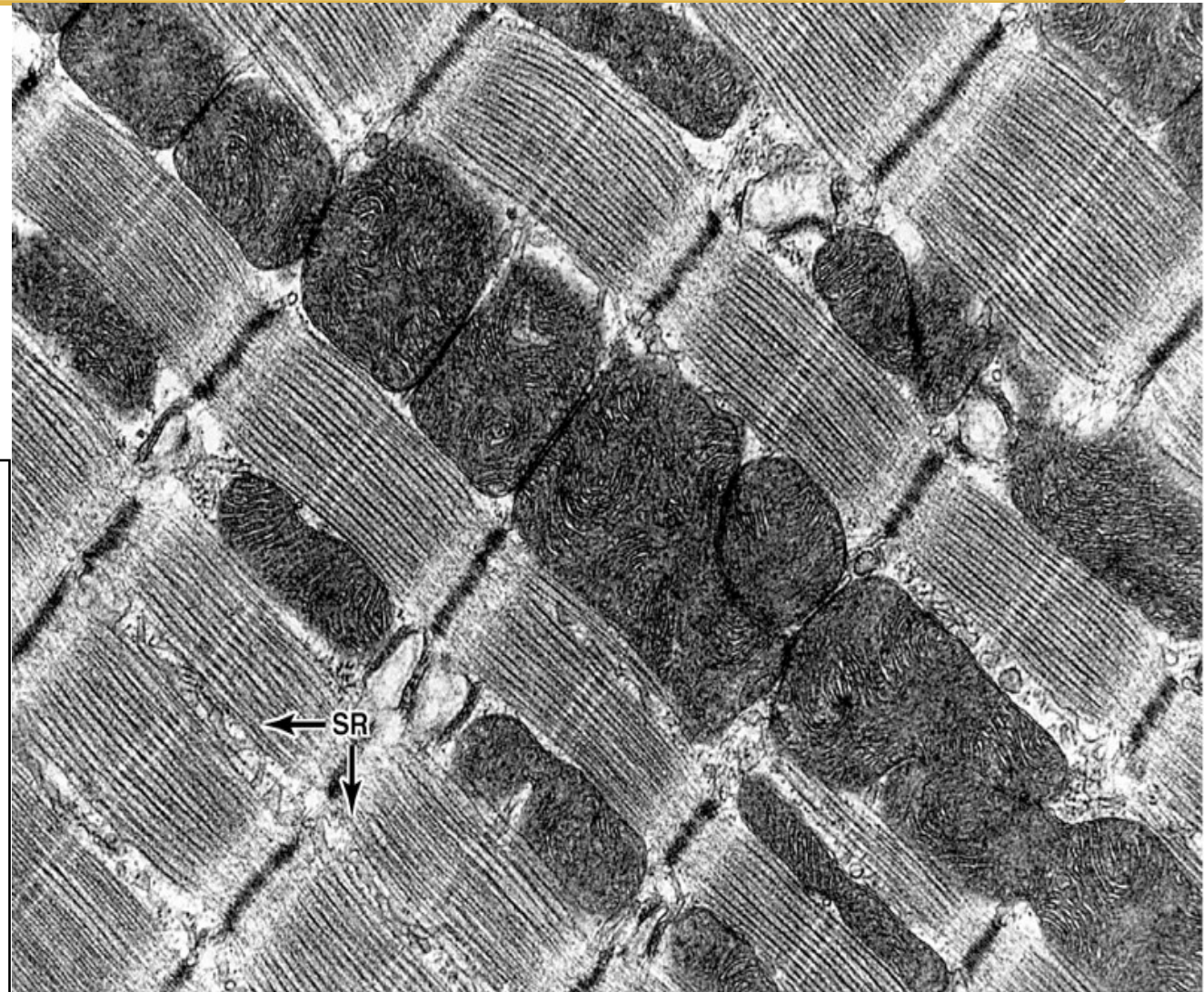
# EM of Cardiac Muscle

4. **Mitochondria**: are abundant (40%), they lie in chains between myofilaments, of large diameter nearly equal length

5. **Lipid droplets & glycogen granules** .....source of energy.

6. **Myoglobin & Lipofuscin** pigment.

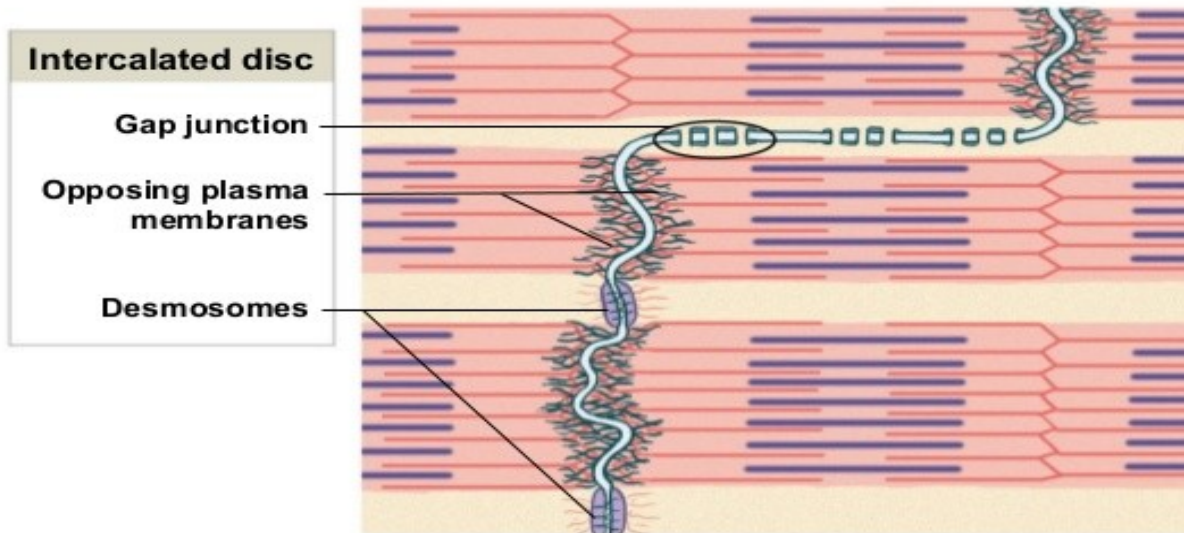
7. **Golgi** saccules.



[https://www.slideshare.net/E\\_neutron/histology-of-muscle-tissue](https://www.slideshare.net/E_neutron/histology-of-muscle-tissue)

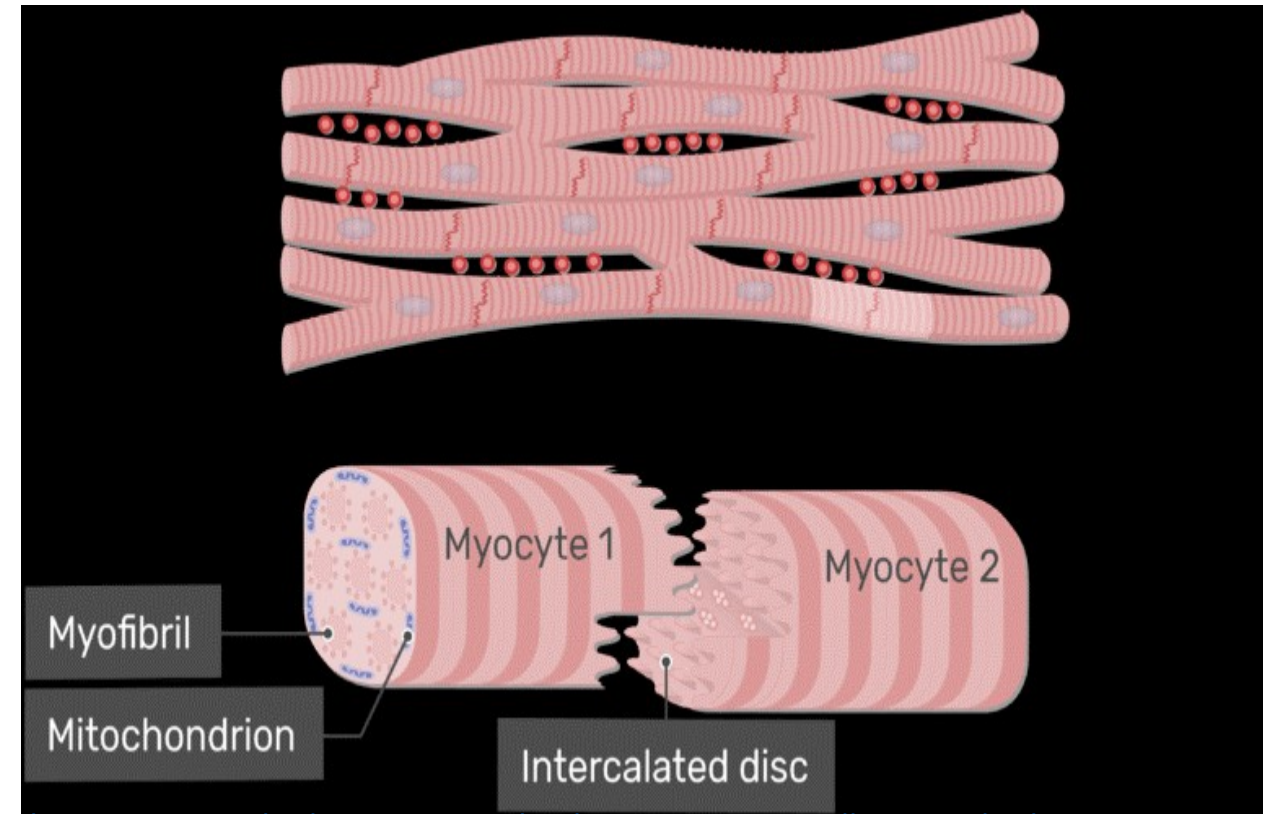
## 9- Intercalated disc

- It is cell junction bet. adjacent cardiac m.
- It is step-like junction formed of transverse & lateral portions.



**b** Structure of an intercalated disc

<https://www.slideshare.net/gwrandall/ch-20lecturepresentation-25361120>



<https://www.getbodysmart.com/circulatory-system/cardiac-muscle-tissue>



# Intercalated disc:



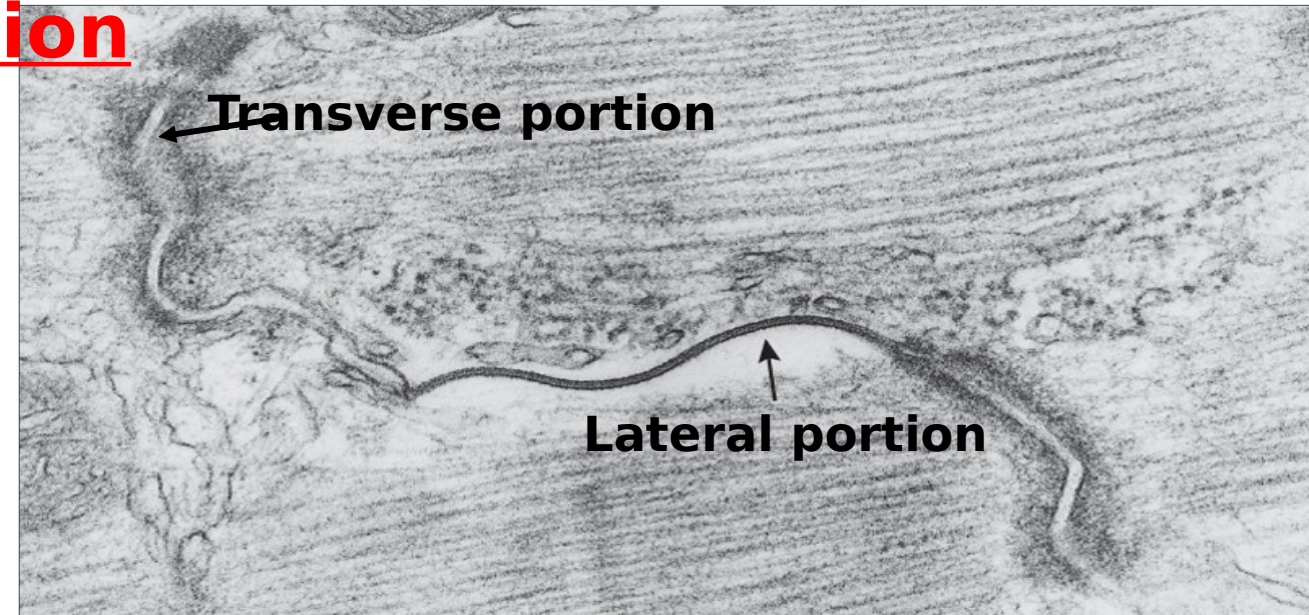
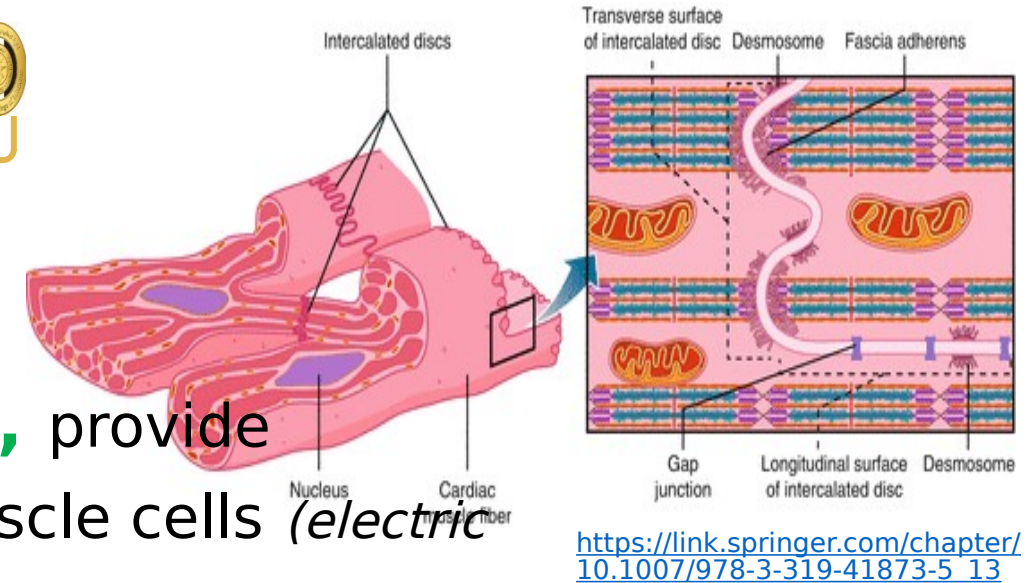
## A. Lateral (longitudinal) portion:

- It is parallel to fibers.
- It is formed mainly of: **Gap junctions**, provide ionic continuity between adjacent cardiac muscle cells (*electric syncytium*).

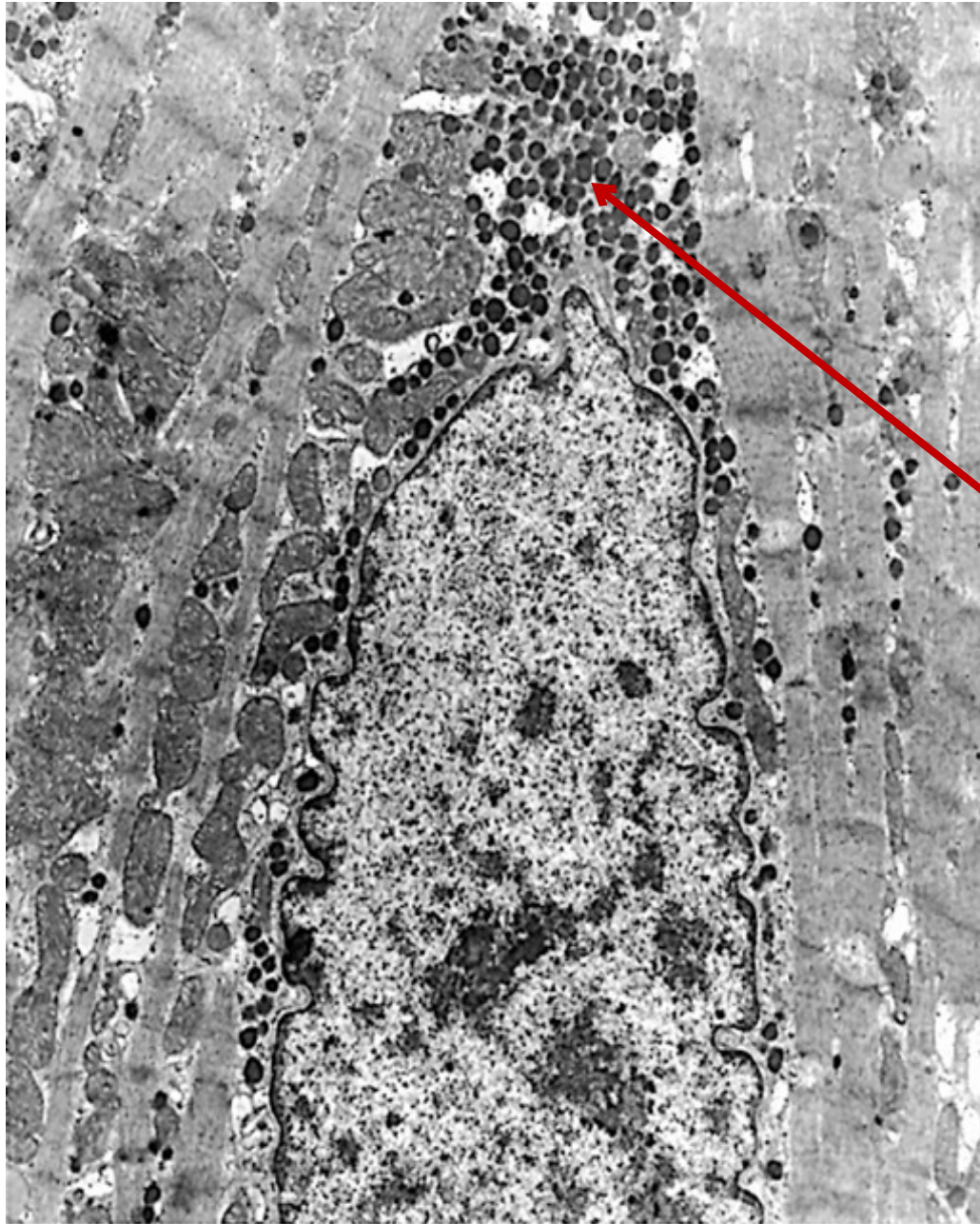
- **Maculae adherens (desmosomes)**, are present to bind the individual muscle cells to one another.

## B. Transverse (vertical) portion

- Across the fibers
- Formed mainly of: **Fascia adherens**, serves as anchoring site for thin filaments in the terminal sarcomere (*mechanical syncytium*).
- Also, **Desmosomes** are







## 10. Atrial granules:

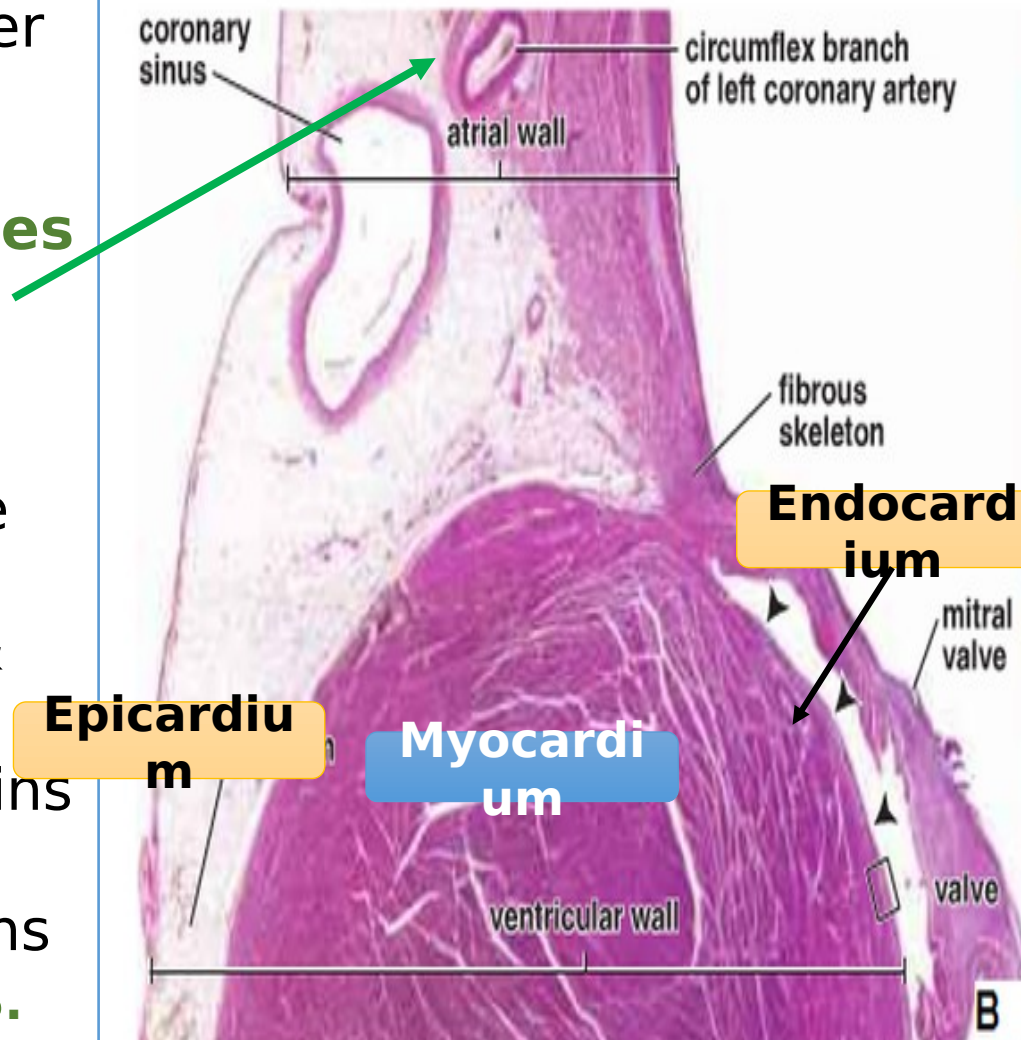
- They are present in **atrial** wall.
- Close to the 2 poles of the nucleus.
- They contain a precursor of a hormone known as **Atrial Natriuretic Factor (ANF)**

## Growth & Regeneration of Cardiac Muscle

- **Cardiac muscle can't divide (devoid of satellite cells). So, no regeneration occurs.**
- **Healing of injured myocardium occurs by fibrosis.** *This pattern of injury and repair is seen in **myocardial infarction (M I)**.*
- **In hypertension, the heart faces extra-force and consequently its wall thickness increase due to **cardiac muscle fibers hypertrophy**.**

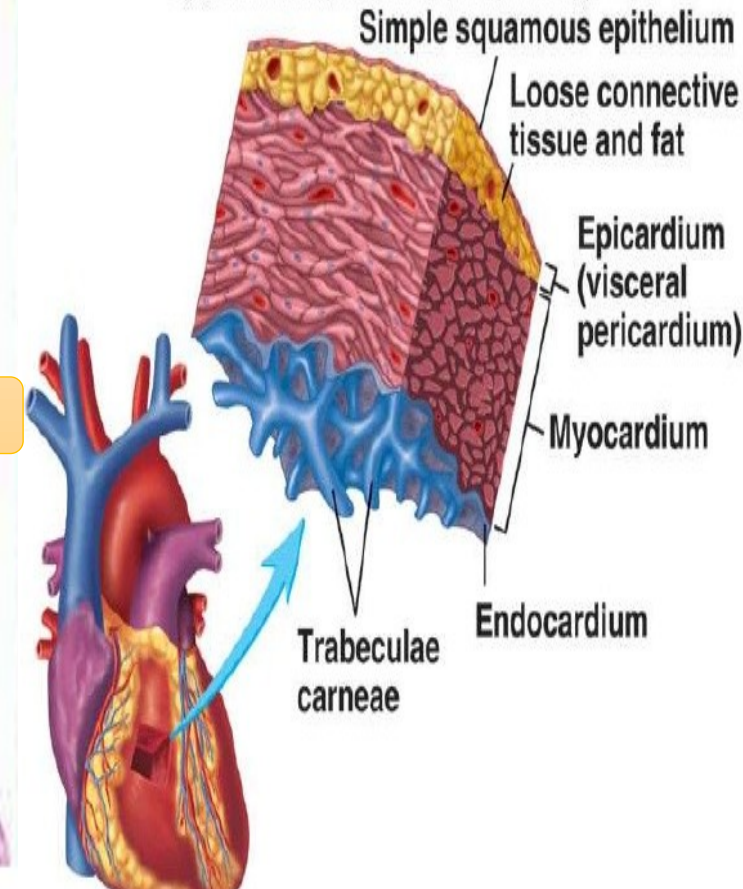
# The structure of the wall of the heart

1. **Epicardium**: (visceral layer of pericardium):
  - Simple squamous ep. + C.T. contain fat & **branches of coronary arteries**.
2. **Myocardium**: cardiac m. run in different direction.
3. **Endocardium**: It lines the heart.
  - Simple sq. endothelium & subendoth. CT
  - Layer of dense C.T. contains elastic f.
  - Layer of loose C.T. contains bl. V. & **Purkinje fibers**.



## Heart Wall

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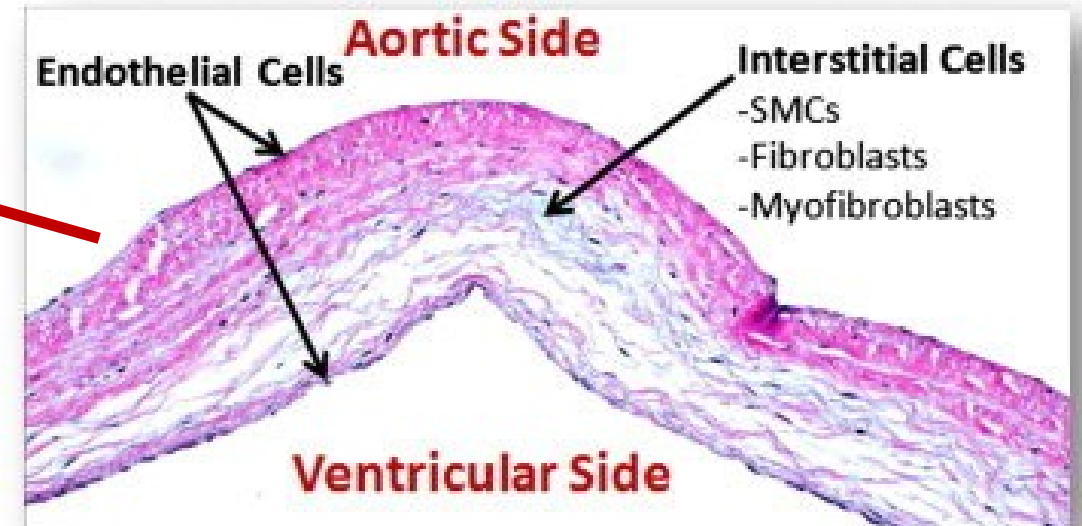
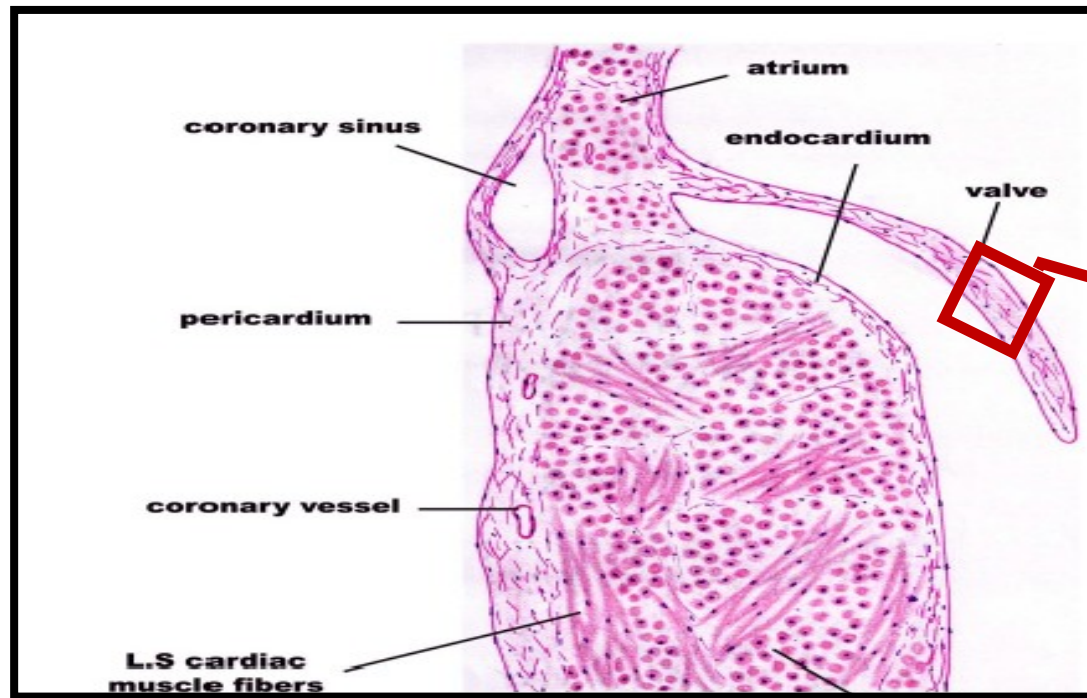




# Valves of the heart



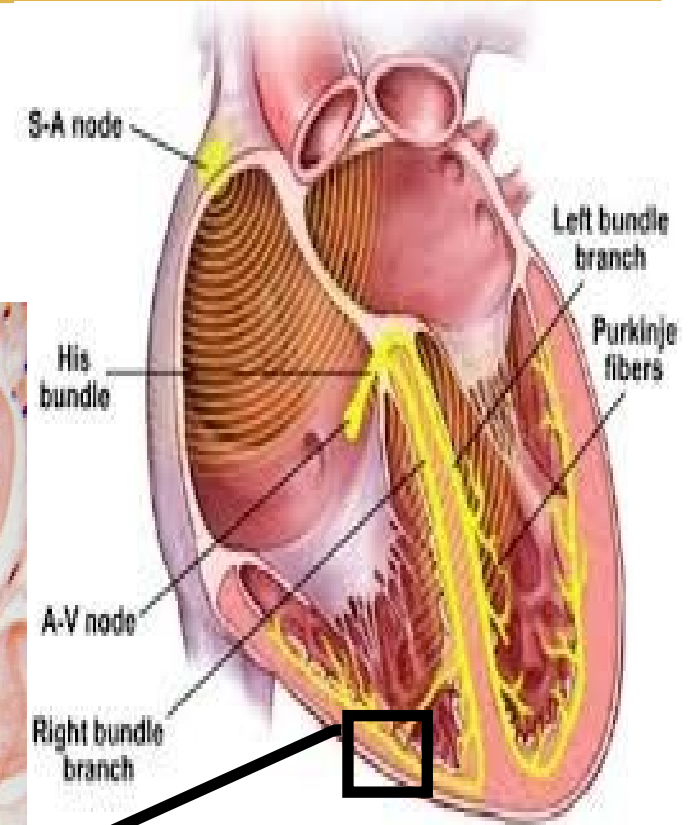
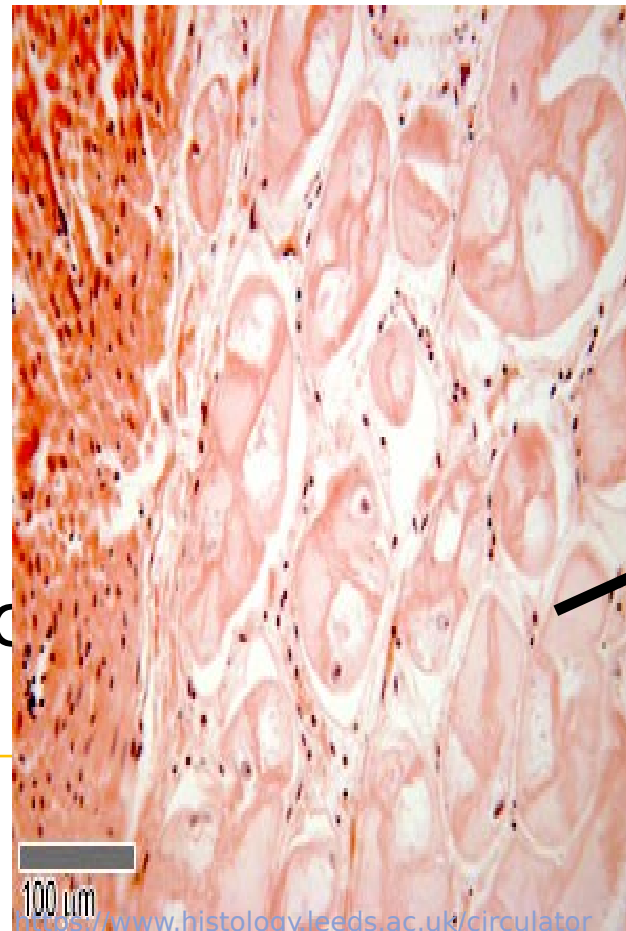
- It is formed of avascular dense C.T. rich in elastic & collagen f.
- It is covered by endothelial cells on both sides.



# Conducting system of the heart



- Moderator band is the right branch of AV bundle of His.
- It is formed of **Purkinje fibers** surrounded by C.T. sheath.
- **It is Ch.Ch.by:-**
  - ✓ Large in diameter (arranged in groups).
  - ✓ Pale & vacuolated (rich in glycogen).
  - ✓ Richly supplied with nerve.
  - ✓ Rapid conduction of impulse.
  - ✓ Few myofibrils & intercal. disc
  - ✓ No diad tubular system.



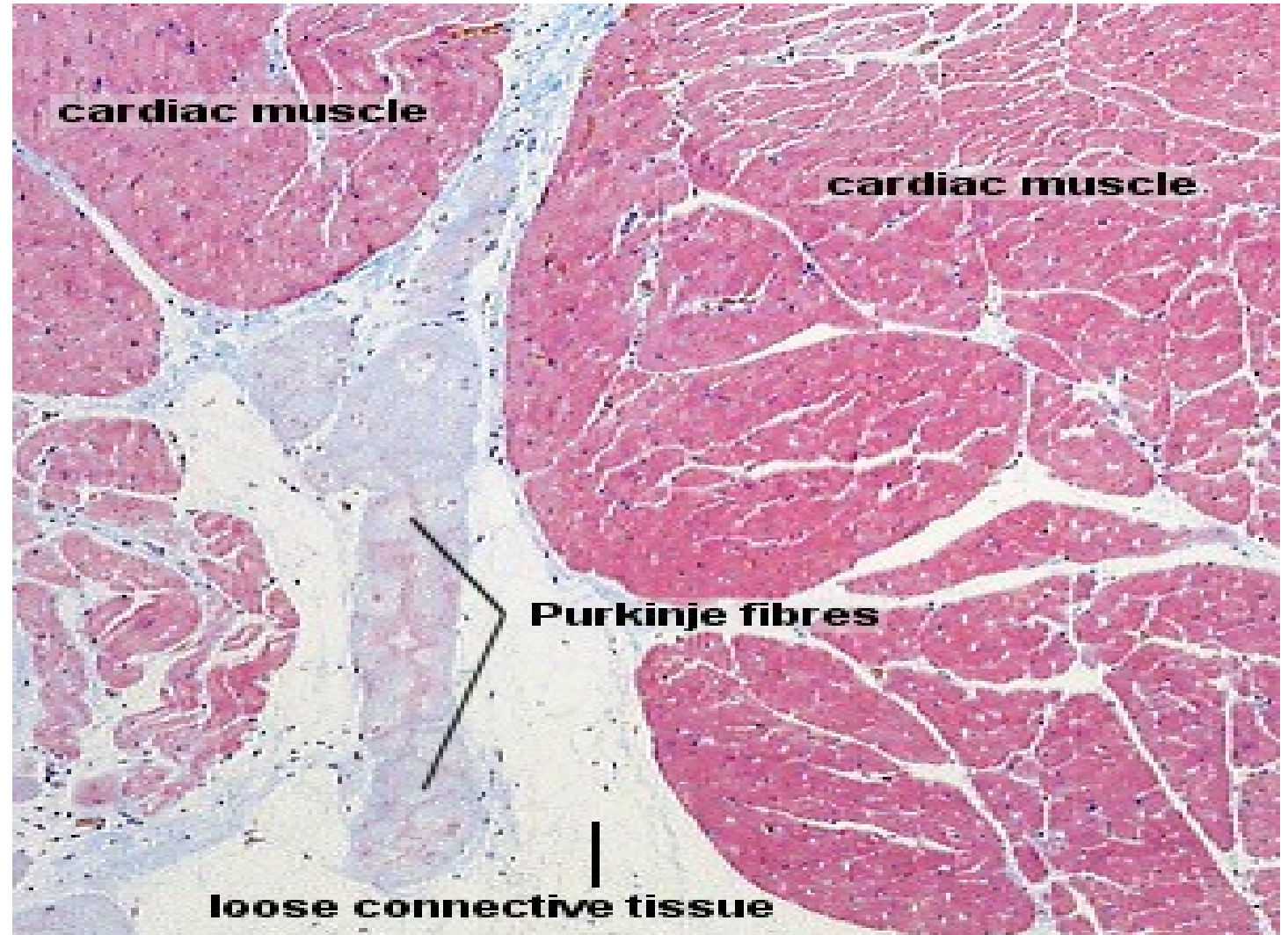
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# Activity



**State the differences between Purkinje fibers and cardiac muscle fibers.**



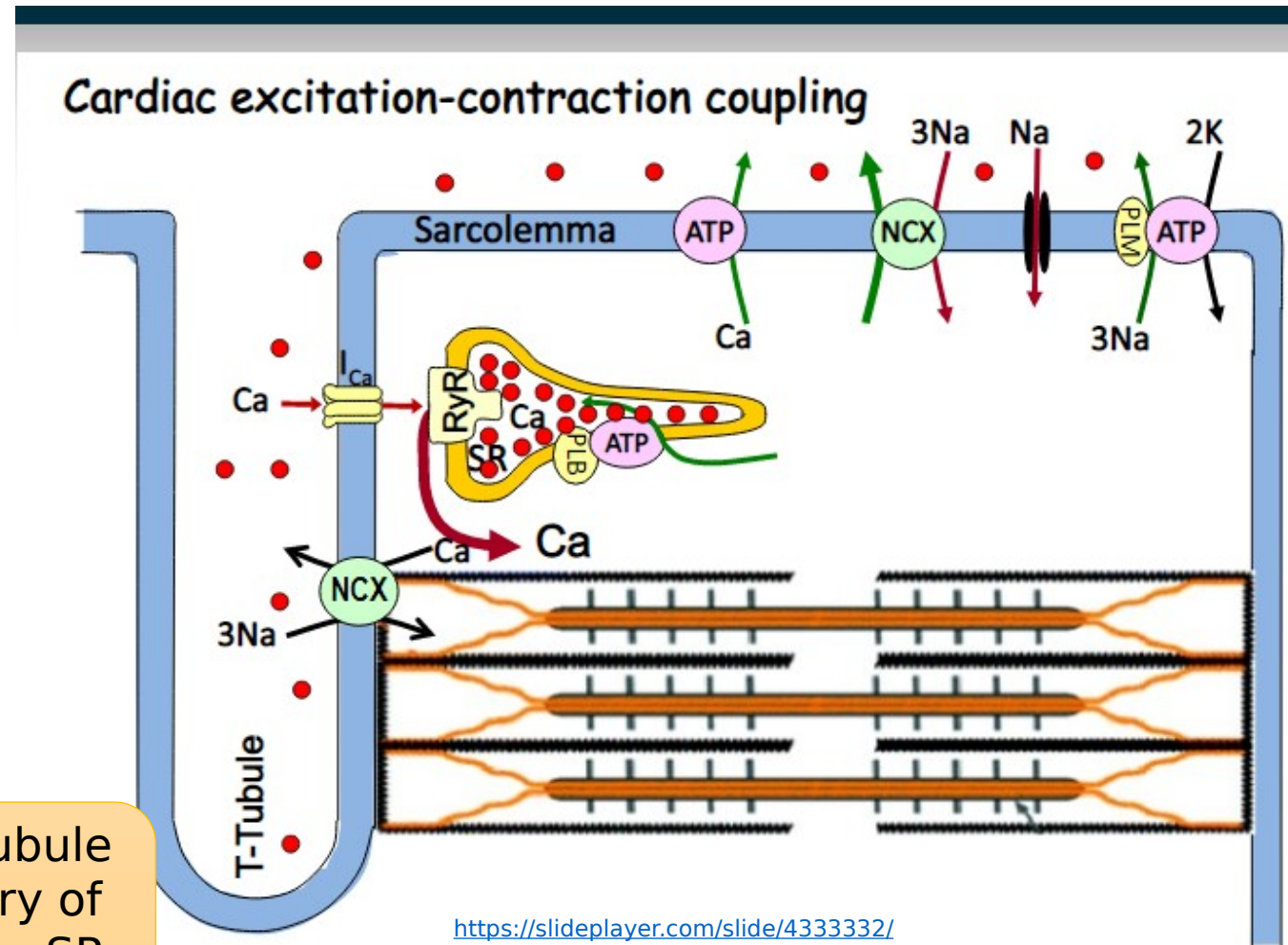


# Medical Application



- **Rapid intravenous injection of calcium salts may cause cardiac arrhythmias and cardiac arrest.**
- **The contraction of heart muscle is greatly affected by changes in extracellular calcium concentration, whereas skeletal muscle contraction is not.**

AP along sarcolemma → depolarization of T tubule → opening of voltage gated Ca channel → entry of extracellular Ca → stimulate release of Ca from SR (=calcium activated calcium release).



# Smooth Muscle Fiber



It is non striated & involuntary.

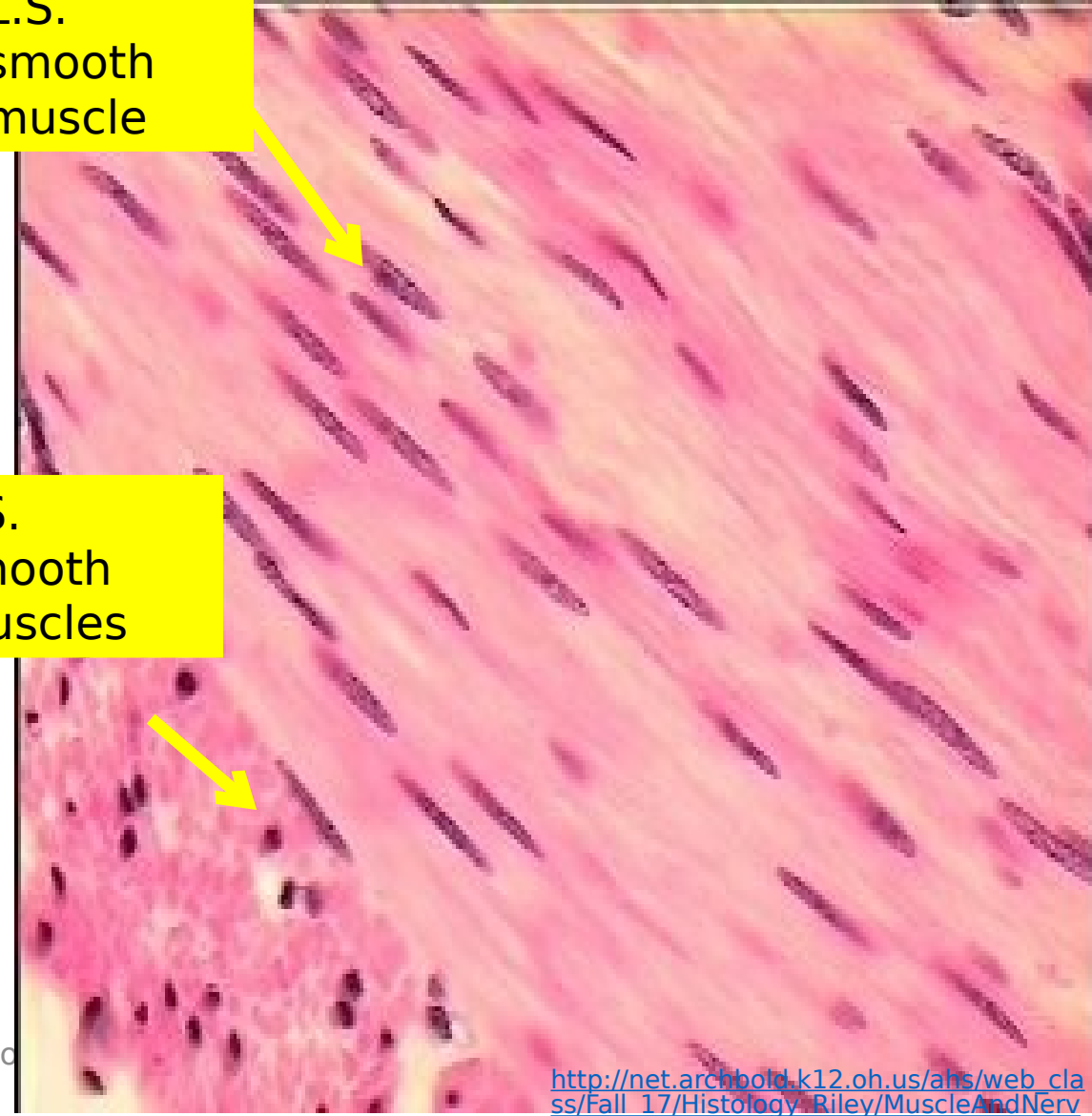
## Sites:-

1. Wall of blood Vs.
2. Viscera

- They are **small**, non branching **spindle** shaped cells
- They have **smallest diameter** of all m.f. ( $3\mu$ ).
- They have **variable length** according to its site
- Each sm. ms cell is surrounded by **endomysium** (thin basal lamina+network of reticular fibers)

L.S.  
smooth  
muscle

T.S.  
smooth  
muscles



# LM of smooth muscle

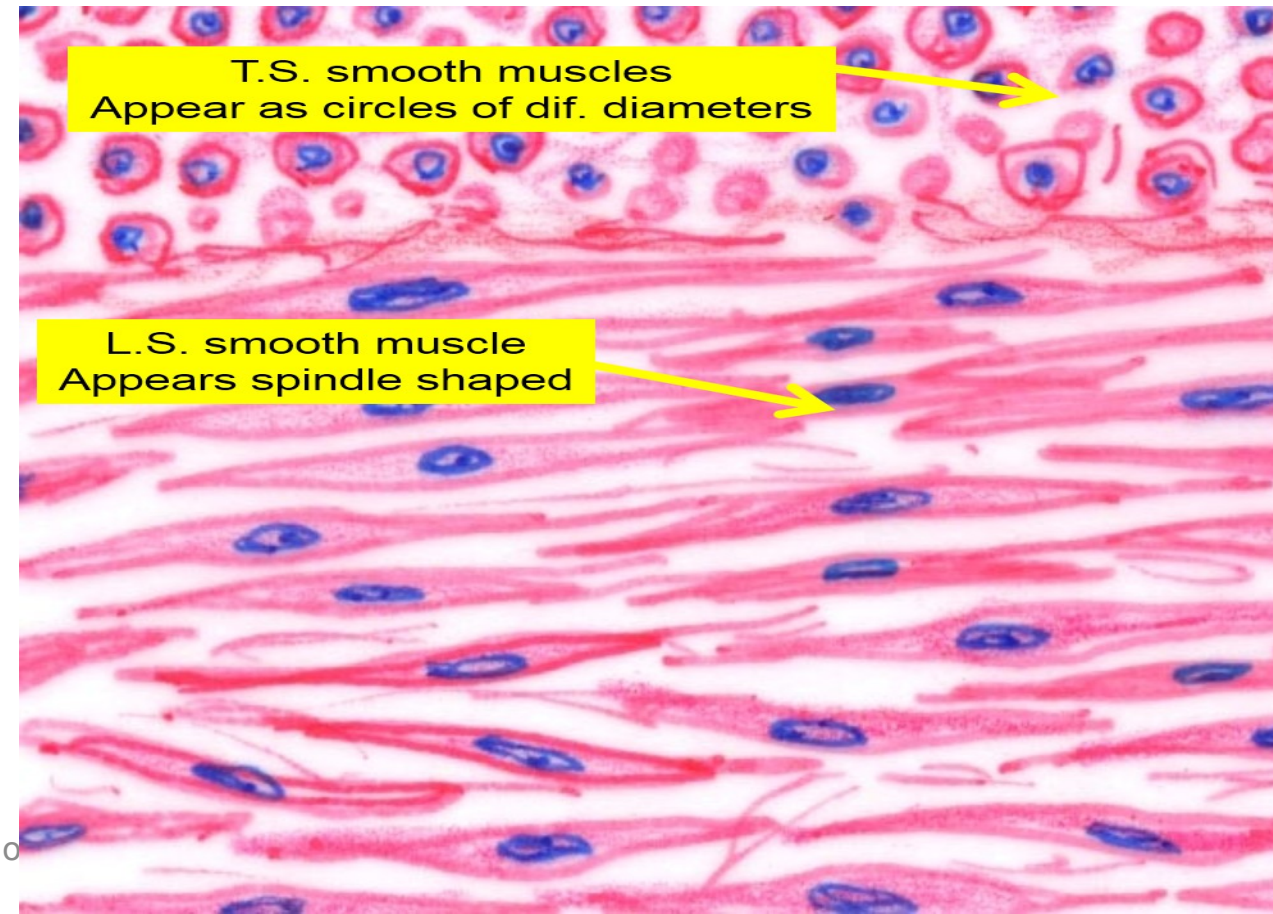


## 1) Cytoplasm:-

- Homogenous & acidophilic
- It contains dark patches called **Dense Bodies** under sarcolemma & in sarcoplasm
- They represent Z lines in striated m.

## 2) Nucleus:-

- Single.
- Central.
- Oval nucleus.





# EM of smooth muscle fiber

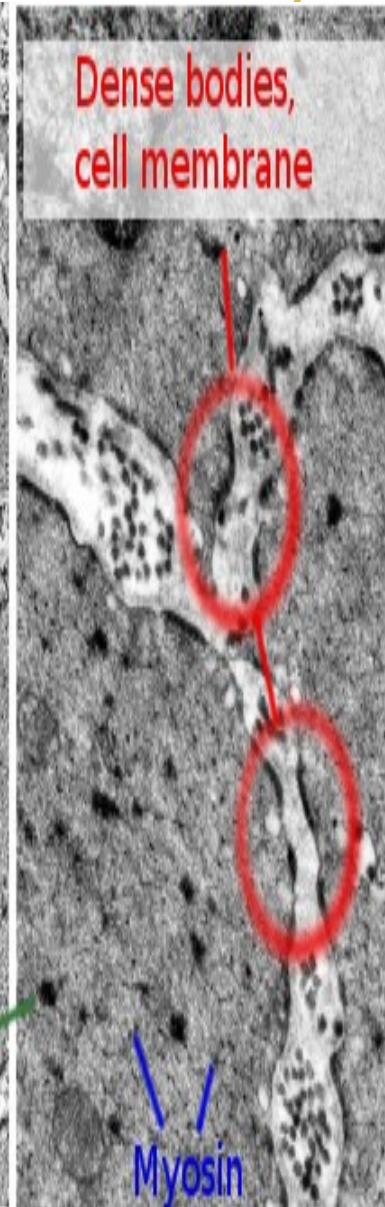
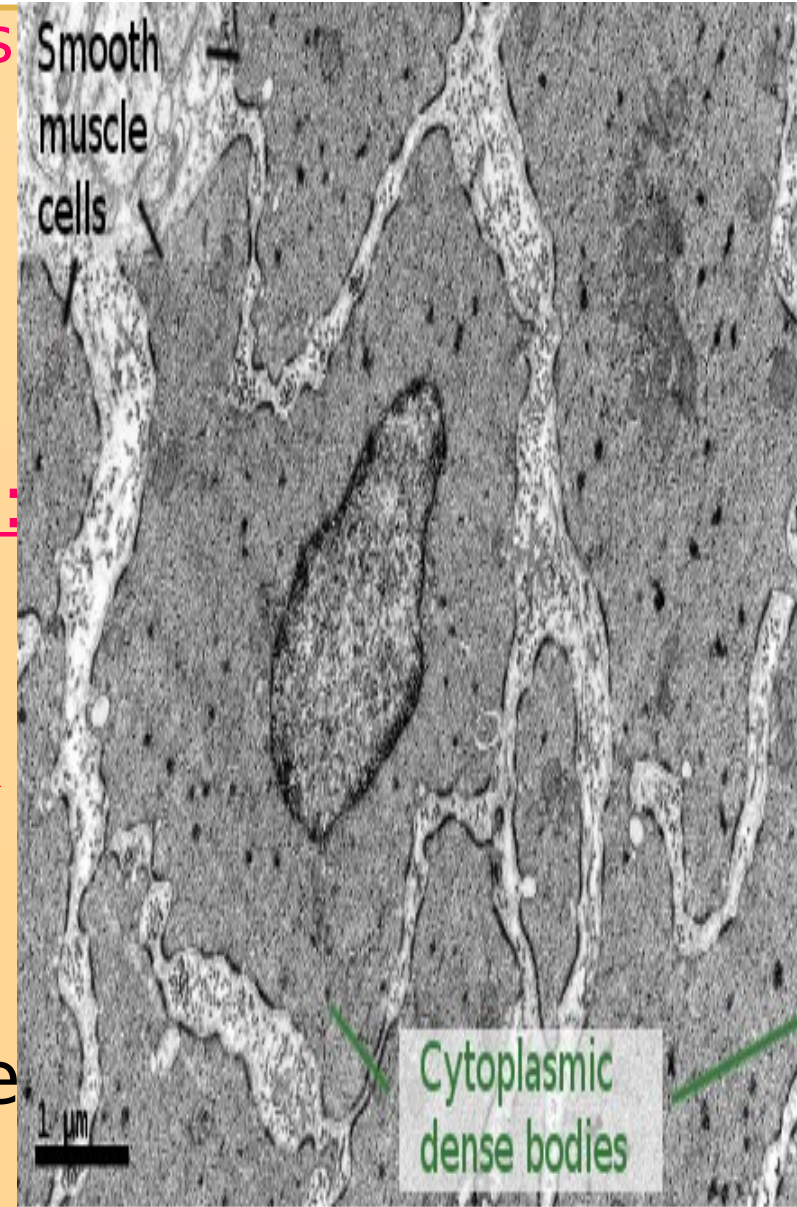


- 1) They contain mitochondria - ribosomes  
- rER & Golgi?????.

They synthesize type III collagen, elastin, external lamina & growth factors.

- 2) They contain 3 types of filaments:

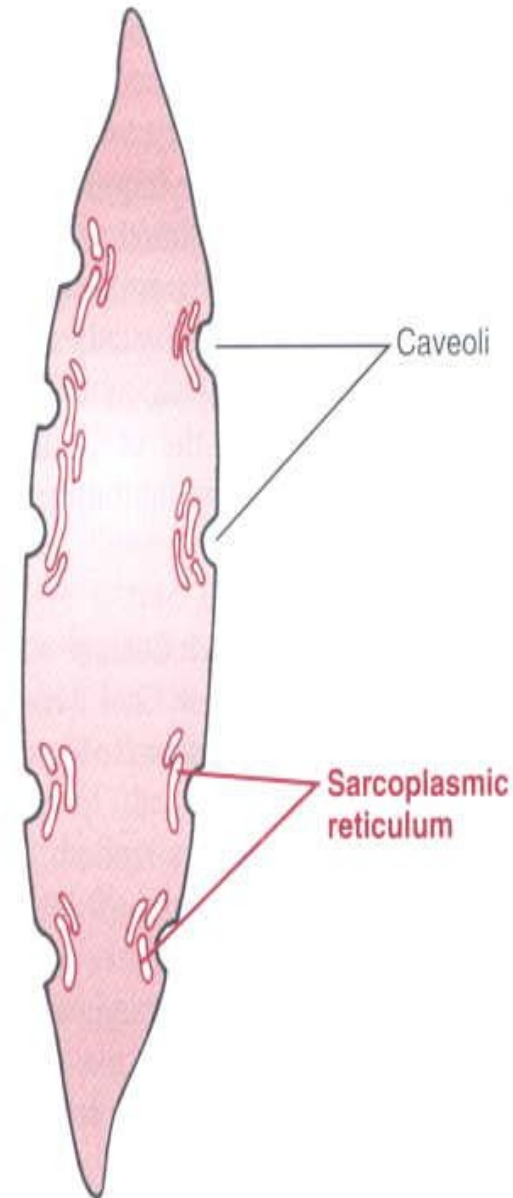
- ☐ Thin filament (**actin**)
- ☐ Thick filament (**myosin**)
- ☐ Intermediate filament (**desmin & vimentin**).
- Thin & thick filaments are arranged irregularly.
- Thin & intermediate filaments are attached to dense bodies.
- No satellite cells
- No striation.



# EM of smooth muscle fiber



- 3) **Sarcoplasmic reticulum:** is poorly developed.
- 4) **T-tubules:** are lacking in smooth ms and are replaced by **Sarcolemmal vesicles (caveola):**
- They are surface vesicles invaginated from cell membrane.
  - They are present along periphery of smooth ms.

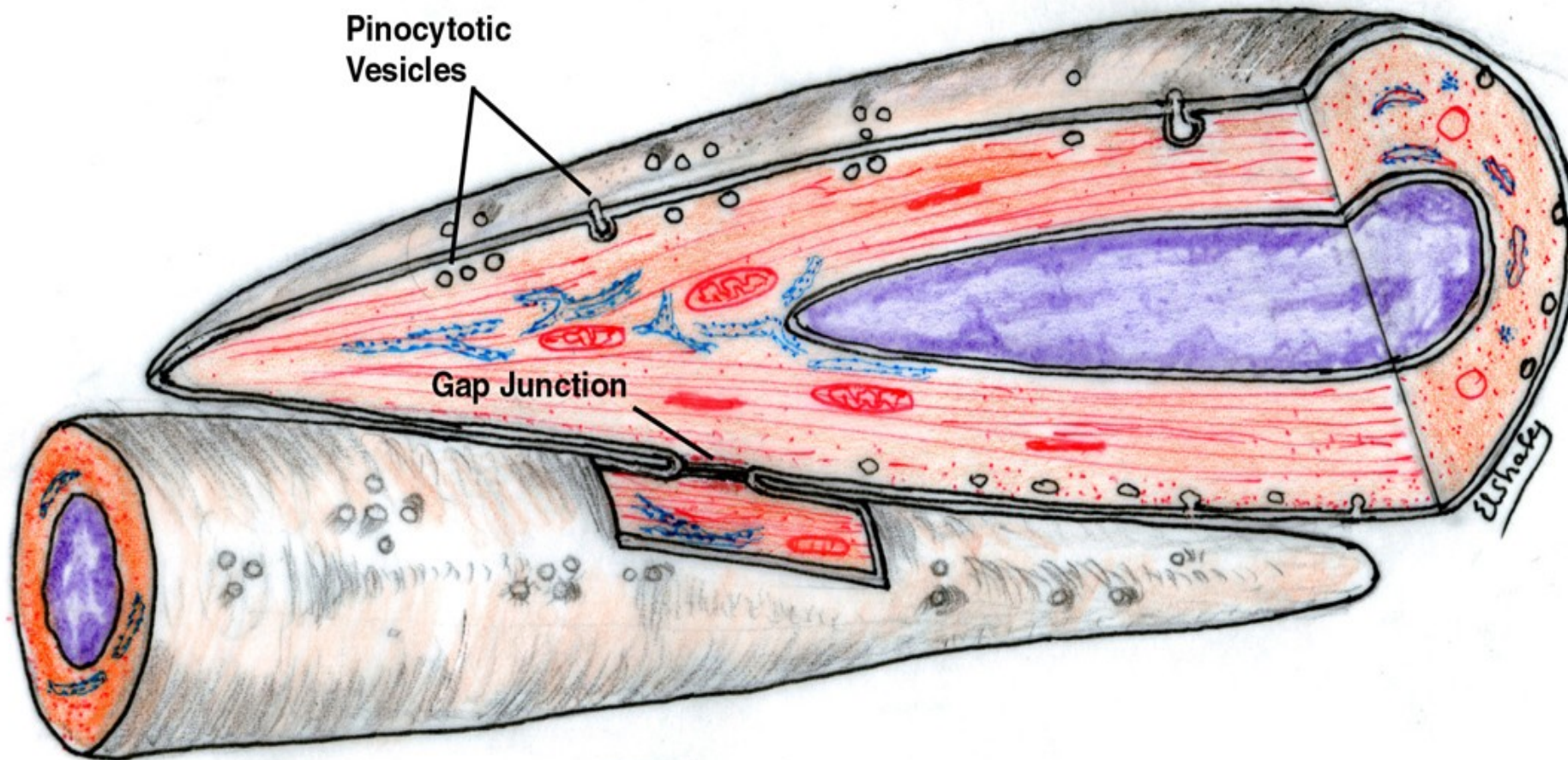




# EM of smooth muscle fiber



**5) Gap junction:** between smooth ms to facilitate spread of excitation





# Growth and regeneration of smooth muscle



## Growth of SMF:-

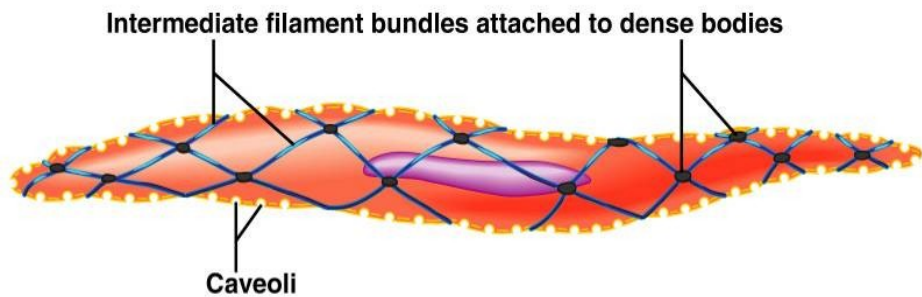
- ✓ They can divide by **mitosis** → increase in number (**hyperplasia**)
- ✓ They can increase in size (**hypertrophy**)

## Regeneration of SMF:-

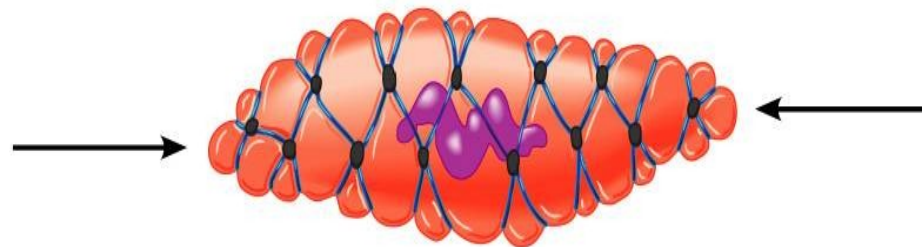
Destroyed smooth ms can be regenerated by:

- Mitosis of nearby healthy smooth ms.
- Division & differentiation of **pericytes** (present in nearby bl.v.) into smooth ms.

# Contraction of smooth muscles

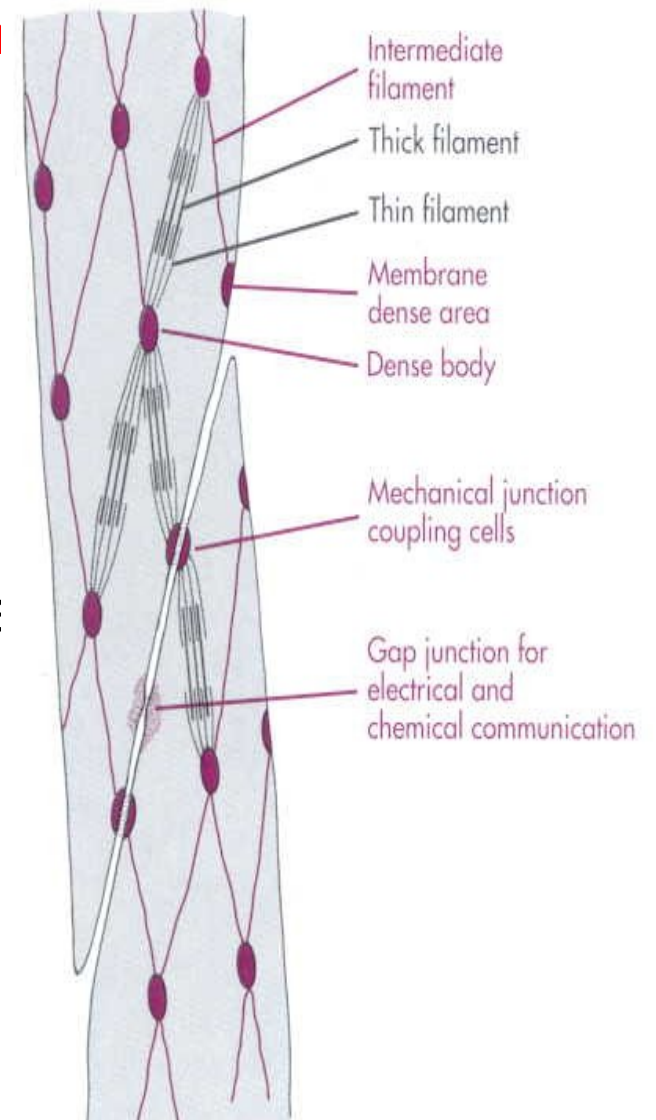


(a) Relaxed smooth muscle cell



(b) Contracted smooth muscle cell  
[www.apsubiology.org](http://www.apsubiology.org), (page  
*Chapter 09: Smooth and Cardiac Muscle*))

- Calcium binds to **calmodulin** activating the myosin to bind on actin binding sites
- Myosin filaments slide on the actin filaments pulling on them.
- Actin pull on the intermediate filaments
- Intermediate filaments pull on the dense bodies changing the shape of the cell

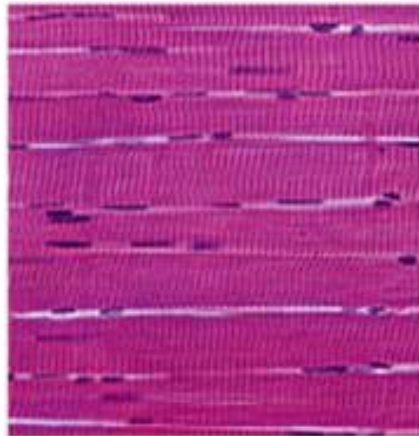


# Compare between different types of muscle tissue?

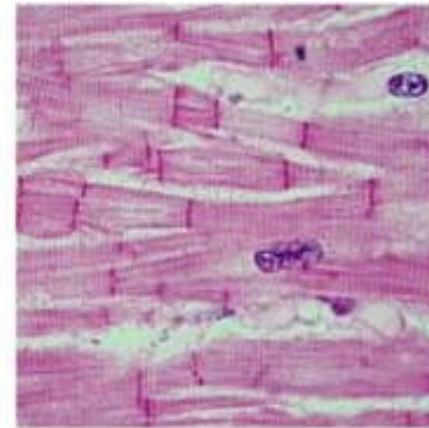
## Lecture Quiz



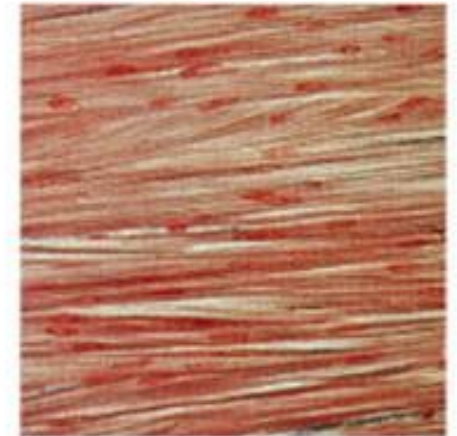
Single, very long, cylindrical, multinucleate cells with very obvious striations



Branching chains of cells; uni- or binucleate; striations



Single, fusiform, uninucleate; no striations





	Skeletal M.	Cardiac M.	Smooth M.
.Shape & size of cells	Long, cylindrical	Blunt-ended, branched	Short, spindle shaped
No. & location of nucleus	Many, peripheral	One or two, central	One, central
Striations	yes	yes	No
T-tubules &SR	Has triads at A-I junctions.	Has diads at Z lines	Has caveolae (no T tubules) & some sER
Gap junctions	no	Yes (intercalated disks)	yes
Sarcomere	yes	yes	no
Regeneration	restricted	none	extensive
Voluntary contraction	yes	no	no
.Distinctive ch ch	Peripheral nuclei	Intercalated disc	Non striated

# Lecture Quiz



- **Purkinje fibers are characterized by which of the following**
  - a. Are part of the myocardial conducting system.
  - b. Formed of bundle of nerve fibers.
  - c. Smaller than cardiac muscle fibers.
  - d. Contain less amount of glycogen than cardiac muscle fibers.



- **Transverse portion of intercalated disc is formed mainly of which of the following junction?**

- A. Gap junction
- B. Tight junction
- C. Fascia adherents
- D. Hemidesmosomes





- **Smooth muscle fibers are characterized by which of the following features?**

A. Dense bodies replace the Z lines.

B. Caveolae replace the T tubules.

C. No sarcomeres are present.

D. All of the above

## Lecture Quiz



- **Gravid uterus increases in size by which of the following way this process occurred?**
- A. Formation of fibrous tissue.
  - B. Division of satellite cells.
  - C. Increased mitotic activity of the muscle fibers.
  - D. Differentiation of pericytes

# Lecture Quiz



- **Both skeletal muscle and cardiac muscle store calcium in sarcoplasmic reticulum. However, cardiac muscle contraction is affected by other calcium channels present in which of the following structures?**
  - A. Mitochondria
  - B. Sarcolemma
  - C. Transverse tubule
  - D. Terminal cisternae
  - E. Longitudinal tubules



# Lecture main points

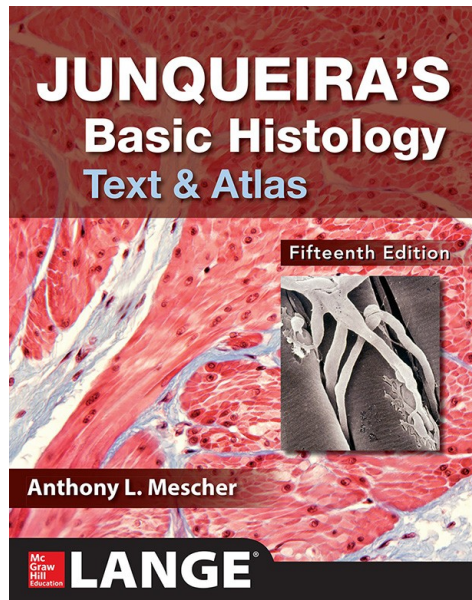


## ✓ Key points:

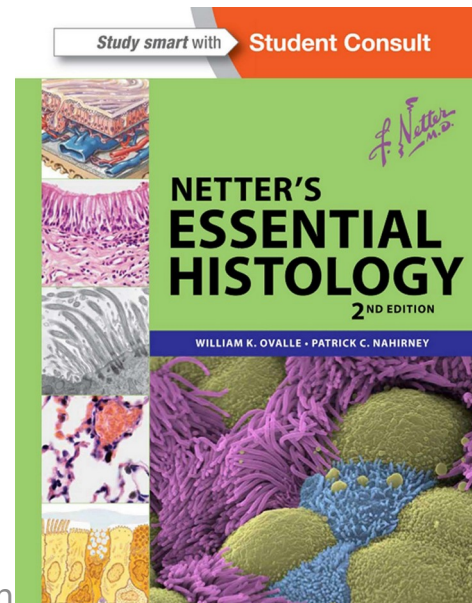
- **L/M of cardiac muscle:** branching and anastomosing with single and central nucleus.
- **E/M of cardiac muscle with special reference to intercalated discs:** diad, wide T tubule, atrial granules, intercalated discs consisted of transverse portion formed mainly of fascia adherens and longitudinal portion formed mainly of gap junctions.
- **Growth and regeneration of the cardiac muscle:** can't regenerate, healed by fibrosis.
- **Structure of the wall of the heart:** formed of epicardium, myocardium and endocardium.
- **Moderator band:** purkinje fibers are paler, larger than cardiac muscle.
- **L/M of smooth muscle:** small spindle shaped cells with single oval nuclei.
- **E/M of smooth muscle:** dense bodies, caveoli, actin, myosin, intermediate filaments, gap junctions, rER, golgi.
- **Growth and regeneration of smooth muscle:** can divide

# SUGGESTED TEXTBOOKS

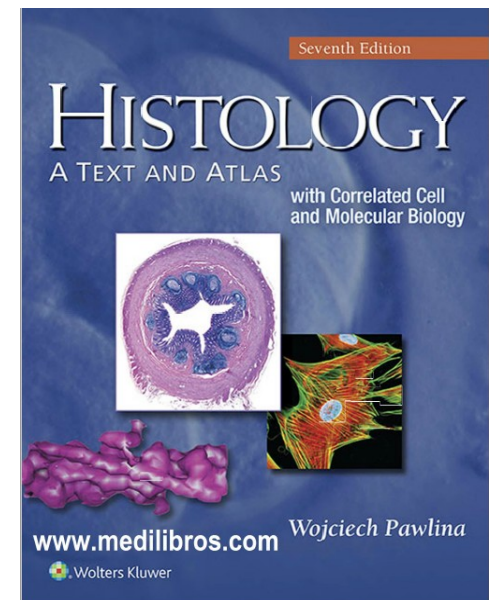
1. Junqueira's Basic Histology: Text and Atlas, 15<sup>th</sup> Edition by Anthony Mescher , 2018.
2. Michael H. Ross, **Histology text and Atlas with correlated cell and molecular biology**, 7<sup>th</sup> Edition, 2015.
3. Netter's Essential Histology, 2<sup>nd</sup> edition, 2013.



New Five Year Program



En ... y ... ile



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